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ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item : C.4.2

United States of America

CONTRIBUTION OF SCIENCE TO THE UNDERSTANDING AND CONTROL OF PLANT DISEASES

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CONTRIBUTION OF SCIENCE TO THE UNDERSTANDING AND CONTROL OF PLANT DISEASES

No. 720

C.4.2

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1. The control of plant diseases is of vital importance in a hungry world. Food is man's most basic need, for science has not yet learned how to sustain human life without it. Nor has man learned how to make food; plants make it for him. Whether he eats the plants directly or feeds them to animals in order that he may have meat and milk, man is completely dependent on plants for his earthly existence. As the number of human beings is increasing at a high rate in the world as a whole, and at an alarming rate in many of the hungrier areas of the world, there is a growing realization that food and feed production must keep pace with human reproduction if we are to avert disaster. It is therefore pertinent to ask: what are the principal obstacles to increased food production; how and to what extent can they be overcome?

2. Poor plants, poor soil, bad weather, weeds, insects, diseases, human ignorance, and human apathy are the most formidable barriers to progress in increasing the productivity of lands available for agricultural production. As the amount of agricultural land in many countries is so strictly limited, primary effort must be devoted to maximizing yields per unit area. Naturally, it also is desirable to increase the efficiency of production by decreasing the amount of labor and other costs. But the most critical factor in many hungry countries is scarcity of food and the land to produce it; hence the basic need is biologic efficiency, with as much economic efficiency as is practicable in satisfying the basic need. Much has been accomplished in replacing poor varieties of basic food crops by better ones and by converting poor soils into better ones. The better-bred and better-fed varieties have high yielding potential; and it is urgent that the potential be attained, not only under favorable conditions but also in the face of adversity. The destructive effects of bad weather, bad pests, and bad pathogens must be prevented or reduced by utilizing the best methods available at present and by devising better ones for the future.

3. The cooperative effort of several groups of scientific specialists obviously is needed to understand and mitigate the destructive effects of the numerous interrelated agents of destruction of economic plants and their harvested products. The enemies of plants useful to man are the enemies of mankind; they must be fought intelligently and persistently, with adequate scientific and educational weapons; for they belong to the triumvirate of man's worst enemies: diseases of economic plants and animals, human diseases, and human prejudice and perversity. But how important are plant pests and diseases?

4. Plant diseases, insects, and weeds reduce the potential agricultural production of the United States almost 23 per cent annually. This represents the approximate equivalent of the production from 75 million acres of crop land and 150 million acres of range and pasture lands, enough to subsist 50 million human

beings. Plant diseases alone cost the United States upwards of $10 billion annually and reduce agricultural production at least 10 per cent. This is deplorable but not necessarily dangerous in food surplus countries like the United States. But losses are higher and much more tragic in their consequences in many countries which are always near the danger line in respect of food supplies.

5. Certain diseases can suddenly and unexpectedly cause widespread and devastating epidemics in all important food and feed crops, thus causing economic distress in most countries and critical food shortages in many. At least a million people died of starvation in India in 1943 because of an epidemic of Helminthosporium blight of rice. Within the past few years there have been destructive epidemics of one or more of the three wheat rusts in important wheat-producing countries of every continent, with losses in the epidemic areas ranging from 40 to 80 per cent. As examples, in 1951 stem rust alone caused a loss of 40 per cent of the durum wheat crop in Chile and 50 per cent of the spring wheat crop in Sweden. In two successive years, 1953 and 1954, stem rust destroyed 75 per cent of the durum crop and about 25 per cent of the spring bread wheat in the United States, with heavy losses in Canada also. As this is being written, in July and August of 1962, destructive epidemics of yellow rust have just taken a heavy toll of wheat in Southern Colombia and Ecuador, and stem rust epidemics are raging in certain areas of Peru and in certain winter-wheat areas of the upper Midwest of the United States.

6. The control of plant diseases is just as important in the betterment of man's agriculture as is the control of human diseases in the betterment of man himself. The consequences of undernourishment constitute one of the most basic human health problems in many countries, comprising hundreds of millions of people. Every increase in food supplies due to controlling plant diseases is therefore a potential contribution to the improvement of human health and happiness in vast areas of the world.

7. The acute economic and human needs for better control of plant diseases are obvious; the critical question is how they can be controlled. The first requisite is adequate understanding of the causes and nature of the thousands of different diseases that attack the thousands of kinds and varieties of economic plants; the second requisite is to devise ways of combating the disease when it is most vulnerable; the third requisite is to educate agriculturists how best to utilize the best available methods of control; the fourth is continuous research to improve known methods and to devise new ones to control those diseases which hitherto have defied man's scientific knowledge and technical skills; and the fifth requisite is to learn how better to anticipate and counteract the disruptive and destructive effects of new diseases and of old diseases in new areas. The importance and the magnitude of these tasks must not be underestimated.

8. The pathogens that cause plant diseases are very diverse and very shifty. The principal groups are microscopic bacteria and fungi; minute nematodes-eelworms; and viruses, comprising ultramicroscopic particles which behave like living organisms in many ways. All pathogens can develop in living plants and weaken or kill them and some can also destroy plant products, living or dead, such as fruits, fleshy vegetables, seeds, and wood or wood products. Each of the thousands of species may comprise numerous parasitic races, very similar in appearance but different in specific virulence or capacity to produce disease. Thus, the fungus species Puccinia graminis, which causes stem rust of wheat, oats, barley, rye, and several hundred species of wild and cultivated grasses comprises several varieties: the variety tritici can attack wheat and barley but not oats; the variety secalis can attack rye and barley, but not wheat and

oats; and there are several other varieties, each with its own particular ability to attack cultivated small grains or grasses. And within each variety there are numerous parasitic races; within the tritici variety more than 300 have been identified by differences in their effects on 12 varieties of wheat and its close relatives. A variety may be highly resistant to some races and completely susceptible to others. And wheat stem rust is not unique in this respect.

9. Plant diseases are indeed shifty enemies because each pathogenic species is a vast confederation of parasitic races, and new races are continually arising by mutation or by hybridization between existing races. Moreover, the populations of many pathogens are astronomically great and their reproductive power is tremendous. Some viruses can increase a million fold within a few days. Theoretically, a single bacterium can produce a progeny of 300 billion in 24 hours. Fungi produce microscopic reproductive spores, so small that a smutted wheat kernel may contain 12 million and the number in half a dozen heads would equal the number of people in the world. On a single barberry bush there often are about 70 billion cluster-cup spores of wheat stem rust, comprising many parasitic races because the sexual stage of this rust develops on the barberry host. Within a week each cluster-cup spore can produce about 250 thousand summer spores on wheat; and each one of these can produce 250 thousand more of its own kind in another week, thus enabling many old and new parasitic races to increase with amazing and dangerous rapidity. On an acre of moderately rusted wheat there are about 50 thousand billion spores, each one a potential wind-borne menace to healthy wheat hundreds of miles away; for rust spores and those of many other fungus pathogens can be disseminated quickly and widely by the wind. As one example, early in a certain crop season south winds carried invisible billions of rust spores from rusted wheat in south central United States 600 miles northward on a front more than 400 miles wide and infected rust-free wheat in an area of a quarter of a million square miles. Many migrating insects also carry numerous viruses and certain other pathogens long distances when aided in flight by favorable winds. The wind's only competitor for the dishonor of being the champion long-distance distributor of plant pathogens is man himself. Man has done himself irreparable harm by carrying all kinds of plant pathogens, as well as insects and weeds, across barriers to their natural dissemination by wind or other carriers. Many of the most destructive pathogens of all major groups of cultivated and wild plants are where they now are solely because man took them there. And, for several reasons, some pathogens were relatively harmless in the areas whence man took them but were devastating in the areas where he put them.

10. There are four general methods of preventing diseases or reducing losses caused by them: exclusion, eradication, prevention, and immunization.

11. Exclusion in its broadest sense includes all measures designed to keep a pathogen out of a given locality or area, whether by individual action or by official regulation. As many pathogens are distributed within countries and between countries only in or on planting materials, it is important to plant only disease-free ones. Two general kinds of protective measures therefore have been developed: certification and quarantines. Official and semi-official systems of inspection and certification of propagative materials vary greatly in respect of legal regulations and effectiveness in application. Many require official inspection of all commercial seed farms and plant nurseries and prohibit the sale of impure or diseased materials. In other cases inspection and certification are optional with the grower, but purchasers in some countries are sufficiently sophisticated as to buy only certified materials. The need and value of certification are greatest when planting materials look healthy but carry a load of invisible pathogens. Potato tubers, as an example, may look healthy but may be carriers of viruses and other pathogens whose destructive effects are easily visible only on growing plants; hence field inspection by experts is the

prerequisite for certification. Certified potato seed-tubers often yield from 25 to 80 per cent more than ordinary "seed", depending on the prevalence of diseases and the efficiency of the certification service. "Use clean seed" is an agricultural extension slogan in many countries; the injunction should be implemented in all countries. Although good national and international certification programs have reduced losses from diseases, they cannot always be relied upon to exclude certain pathogens from areas in which they do not exist. The resort has been quarantines.

12. Plant quarantines are plant public-health measures. Most countries have suffered disastrous experience because of the introduction of foreign pests and pathogens. More than 50 per cent of the major plant pests and diseases in the United States are of foreign origin, and many other countries can equal this record; consequently, most countries have tried to protect themselves by means of quarantine regulations. Some of the early ones were ill-conceived and poorly executed; however, they have become more rational and realistic as a result of increasing scientific knowledge and experience. Quarantines can be effective. Coffee rust, which devastated coffee plantations of Southern Asia about 70 years ago and still is destructive in the Eastern Hemisphere, has been kept out of the Western Hemisphere by constant vigilance; and many other diseases of both hemispheres have been similarly contained, with very great mutual benefits. Plant quarantines, like most legal restrictions, may be irritating but they are as necessary as those designed to protect the health of domestic animals and of human beings. The criticism that some quarantines have been either misused or ineffective can be made against many measures designed to improve or protect agricultural production. The remedy is to improve them, not to abolish them.

13. Eradication, as a plant public-health measure, is often associated with quarantines. Although the individual grower often practices eradication in "roguing" his fields, the present discussion is restricted to organized governmental attempts to promote plant public-health by destroying pathogens or pests completely or by large-scale eradication of plants which harbor pathogens and constitute a menace to agriculture. Every country needs a "plant-disease survey" agency to obtain information on the occurrence, distribution and destructiveness of old diseases and to detect new pathogens early enough to permit eradication.

14. The results of four eradication campaigns are eloquent of actual and potential accomplishment. Flag smut of wheat was introduced on imported seed wheat into a localized area in Mexico in 1949, and the following year the destruction ranged from 15 to 40 per cent. Mexican authorities promptly burned the infested fields, imposed a three-year embargo on shipment of wheat from the area, and the disease has not appeared subsequently. Likewise, the bacterial citrus-canker disease has been practically eliminated from Florida and neighboring states of the U.S. Introduced from the Orient, the disease was first observed in Florida in 1913. Within a few years state and federal agents destroyed 3 million infested trees by means of a blast-flame, and the disease has not appeared in Florida since 1927. It has either been eradicated completely from the U.S. or reduced to impotence. The destructive cedar rust of apple has long been controlled in certain apple-growing areas of eastern United States by systematic eradication of the red cedar (Juniperus sp.) without which the rust cannot persist.

15. There is a long and variable record of barberry eradication campaigns to control stem rust of wheat and certain other small grains. The first known plant proscription law, enacted in Rouen, France, about 1660, required the destruction of barberry bushes because farmers insisted that rust was always exceptionally destructive near them. Similar observations in various other areas, including several New England colonies of North America, motivated legislation

against the "baneful barberry". The researches of de Bary furnished the scientific explanation, in 1865, of the long-observed baneful effect of the "baneful barberry". It was simple: one stage in the complex life cycle of stem rust develops on barberry, and only on barberry. This discovery stimulated much more anti-barberry legislation. Then the question arose as to whether the barberry stage was essential to the persistence of the rust. A reliable answer had to await extensive investigation. The fact is that rust cannot persist independently of barberry where cold winters force the summer stage of the rust into a dormant overwintering stage, which resumes activity in the spring and can infect only the barberry, on which the sexual stage of the rust develops. From barberry the rust can pass again to wheat and other susceptible grasses and propagate itself in its summer stage so long as summer lasts. In warm, relatively frost-free areas where summer is virtually continuous the rust can persist independently of the barberry.

16. The barberry therefore is a powerful ally of stem rust; it helps it to persist in certain areas, and because it is host to the sexual stage, it is fertile breeding ground for new and dangerous parasitic races. Barberry eradication therefore decreases the amount of rust and reduces the number of kinds or parasitic races of the rust.

17. Barberry eradication has resulted in practical control of stem rust in some areas; in others it has spectacularly reduced the frequency and severity of epidemics; in others it has merely mitigated the annual rust menace; and in most cases it has at least prevented a bad situation from becoming worse. The value of certain programs must be measured not only by comparing the actual present situation with the actual situation in the past but also with the potential present situation: what would the present situation be if the program had not been undertaken? As an example, 296 million barberry bushes were destroyed in the northern United States, 1918-1943. Had these bushes been present during the past 20 years they could have produced, assuming 50% of maximum infection, 9×10^{18} spring spores annually, enough to inoculate the total acreage of wheat in the United States and Mexico with 100 billion spores an acre. But there would also have been far more than 296 million bushes, for they had run wild and were multiplying and spreading rapidly. Moreover, the number of prevalent parasitic races decreased and permitted certain rust resistant varieties to thrive longer than they could have with an abundant source of new races on barberries near every wheat field. We need to sharpen, raise, and broaden our sights with respect to the ultimate values of plant public-health programs.

18. Many diseases can be controlled satisfactorily by treating seeds or by spraying or dusting growing plants with appropriate chemicals. Progress in chemical control has been revolutionary during the past few decades. Many more fungicides are available, many are more effective for certain purposes, and many cause less damage to the seed and plants to which they are applied. A few decades ago a few fungicides were used, like patent medicines, for many purposes; now many more are used, but each one for specific purposes. In the past almost any plant scientist could prescribe fungicides; now it takes an expert. As examples, a certain nurseryman and orchardist lost $10,000 because he followed bad advice and applied a good fungicide to the wrong kinds of plants, but he gained $3,000 in a small apple orchard by following good advice in substituting in the last of four spray applications a better fungicide than he had been using. Of course, these two case histories could be multiplied many fold, both in kind and in magnitude. Research is continually providing new and better chemicals for controlling the numerous kinds of diseases and it is urgent that growers be taught how best to use them and how to avoid misusing them. But this is a job for competent specialists.

19. The only presently practicable way of controlling many diseases is by means of appropriate chemicals. At best, however, most chemicals help prevent but do

not cure diseases, and their effective use adds to the cost of production, sometimes but little and sometimes a great deal. The control of certain smuts and other seed-borne diseases of many crops by seed treatment requires a single simple and inexpensive operation, with a profit of several hundred per cent on the investment. The protection of growing plants, however, often requires several, more expensive operations. Thus, it requires from 10 to 15 spray applications in some areas to protect bananas against destruction by the sigatoka disease, thereby increasing the cost of production about 20 per cent. A single application of a fungicide to potato fields to protect them against late blight costs about $3.00 an acre. As 10 applications are necessary in many areas, the cost of protection is $30 an acre. But certain semi-resistant varieties have been protected by 4 applications, at a cost of $12 an acre; hence the resistance has saved the grower $18 an acre.

20. The ideal way of controlling all plant diseases would be by means of resistant varieties, both to reduce the cost of production and to control many extremely destructive diseases that cannot now be controlled economically by any other means. Every contribution that the plant can make to its own protection against disease relieves man of just that much worry, work, and expense in protecting them. The need for resistant varieties is evident, but how feasible is it to produce them? There is no simple, categorical answer.

21. The degree of success in programs of breeding for disease resistance has varied widely: some were completely successful, some were partly or temporarily successful, and others were relative or complete failures. But much was learned, both from the successes and from the failures. And it is essential to progress that we profit by the lessons learned from both. The scientific foundation for rational procedures in breeding for resistance began to be laid about 50 years ago, and it is still in process of construction. At least we have learned enough not to repeat past mistakes and to improve concepts and procedures.

22. The general lesson learned from past experiences is that breeding programs must be more broadly based, because most crop plants and their pathogens are broadly based. There are thousands of varieties of wheat, rice, maize, sorghums, sugarcane, potatoes, and of most other important food or feed crops in the world, with many different degrees of susceptibility or resistance to diseases. And there are hundreds of species of pathogens, each comprising numerous parasitic races, with different degrees of virulence for species or varieties of crop plants. The genes for disease resistance and other desirable characters are scattered in many varieties in many parts of the world; and the genes for virulence are scattered in many parasitic races in many parts of the world. The problem is to locate, assemble, and combine the genes for resistance into new varieties and test them against an adequate sample of pathogens under an adequate sample of environmental conditions. Unless this is done the new varieties are likely to be disappointing. After having been grown for a few years, many varieties were found to be exceptionally susceptible to diseases other than those against which they were bred or to have merely temporary, local, or variable resistance to those against which they were bred. Disappointments should be restricted to experimental plots; they are too painful when suffered on thousands of farms.

23. Successful breeding for disease resistance usually requires cooperation between geneticists and pathologists. It is unscientific to engage in a breeding program without adequate knowledge of what is being bred and against what it is being bred; the geneticist or plant breeder must know the varieties of the crop plant and the pathologist must know the number, distribution, and degree of virulence of the parasitic races of the pathogen. The plant selections or hybrids must then be exposed to infection by an adequate sample of the parasitic races, under conditions that permit them to do their worst. This is not easy but it is

essential. Many varieties have succumbed to parasitic races against which they had not been tested before distribution; and many were resistant under the environmental conditions of the breeding plots but not under those which they encountered in other localities. The ideal is to locate, collect and identify all parasitic races in the region in which the variety is to be grown, then inoculate the breeding nursery with them under conditions which permit rigid selection. The resistant lines should then be further tested at different temperatures and other conditions in plant houses to ascertain the possible variability in their resistance. When facilities are not available for an ideal program, nurseries should at least be inoculated with a composite sample of diseased materials from many varieties and several localities in the area, in the hope of including an adequate sample of important pathogens and their parasitic races. The selected lines should then be tested in several seasons and at several places.

24. International cooperation can aid greatly in improving disease control by means of resistant varieties. Varieties may be highly resistant to all parasitic races of the pertinent pathogen in one country but susceptible to those in another. If the pathogen is not distributed by wind or other agents of dissemination beyond the control of man, they can be excluded by quarantine or other phyto-sanitary regulations. Those which are wind-borne, however, are likely to spread sooner or later to all countries within homogeneous geographic areas. International cooperation in testing and breeding of varieties can therefore be mutually beneficial. Indeed, it is essential to most rapid and permanent progress.

25. Disease resistant varieties have been of incalculable value in all countries where available scientific knowledge and technical skills were utilized in breeding programs. In the United States, flax wilt, cabbage yellows, and several other wilt diseases have been kept under control for almost 50 years; the sugar beet industry of western United States was saved from annihalation by means of varieties resistant to virus curly top; and losses from some major diseases of virtually all major crop plants have been substantially reduced. The spring bread wheat area of northern U. S. and Canada has been protected against the scourge of stem rust in about 20 years of the past 40, not a perfect record but a good one. Within the past 20 years wheat production has been doubled in Mexico, as a result of the production of superior, rust-resistant varieties and better cultural methods. Several western European countries have improved and partly insured agricultural production similarly.

26. Much still remains to be learned about plant-disease control, but what has been learned should be utilized as fully and as widely as possible. It is hard for a teacher to teach what he does not know. The transmission of successful experiences from those countries which have had them to those which have not is a job for competent specialists.

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SUMMARY

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By E.C. STAKMAN,
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CONTRIBUTION OF SCIENCE TO THE UNDERSTANDING AND CONTROL OF PLANT DISEASES

No. 720

C.4.2.

By: E. C. Stakman

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SUMMARY

1. Plant disease control is an essential phase of all agricultural improvement programs.

2. Plant diseases reduce agricultural production at least 10 per cent annually in those countries where protective measures are used efficiently and more in those countries where they are not. In addition, some of the destruction attributed to bad weather, weeds, and insects must also be charged to diseases, which often aggravate the direct damage caused by those agents. Many diseases, such as rusts of wheat, rice blasts, and potato blight, often become devastatingly epidemic and destroy millions of bushels of basic foods in a single year, causing economic disruption and distress in most countries and disastrous food shortages in many.

3. Science and technology have contributed greatly to the understanding and control of plant diseases during the past several decades; and it is imperative that the increased knowledge and better techniques be effectively used to help increase and ensure food production, especially in the hungrier areas of the world.

4. There are thousands of kinds of plant diseases on thousands of kinds and varieties of cultivated and wild plants. They can be caused by bad weather or bad soil; by living pathogens, such as bacteria, fungi, and nematodes; or by pathogenic viruses. Pathogens are dangerous and shifty because each species may comprise numerous parasitic races, because they can multiply with amazing rapidity, and because they can be disseminated quickly and widely by the wind or insects or by means of man's commerce in seeds and other plant materials.

5. Different kinds of diseases must be combated by different methods: phytosanitary services, the use of chemicals, and the development of resistant varieties. Each method requires the services of specialists. Phytosanitary services, such as seed certification, quarantines, and eradication campaigns, are highly effective against many diseases if efficiently operated. Many diseases can be prevented by disinfecting seeds or by spraying or dusting growing plants at appropriate times with appropriate chemicals, but such treatments are ineffective and sometimes harmful if inappropriately used. Prescriptions for the best use of chemicals should be made by experts. The development of disease-resistant varieties is one of the most urgent needs in agriculture, for there is no other practicable method of controlling many of the most destructive diseases of basic food and feed crops. But success depends on adequate scientific knowledge regarding the complexities of the crop plants and their pathogens and the complexity of their interrelationships. Breeding for disease resistance and the other methods of disease control require inter scientific-guild and international cooperation, because the problems and the diseases often transcend the boundaries between scientific disciplines and between nations.

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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
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Agenda Item: C.4.3

Food and Agriculture Organization

THE PLACE OF FRUIT AND VEGETABLE CROPS IN FOOD PRODUCTION IN THE LESS DEVELOPED AREAS OF THE WORLD

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THE PLACE OF FRUIT AND VEGETABLE CROPS IN FOOD PRODUCTION IN THE LESS DEVELOPED AREAS OF THE WORLD

by

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1. The role of fruits and vegetables in supplying the nutrients that are today in short supply in the diets of developing nations is gaining recognition. The importance of fruits and vegetables does not lie in their contribution of carbohydrates or fats to the diet, but rather as providers of the vitamins, mineral salts and,in the case of legumes, the proteins that are indispensable for human health.

2. Paul C. Mangelsdorf of the Conservatory of Botany of Harvard University (1) and more recently John D. Rockefeller III, President of the Rockefeller Foundation, in his inaugural speech (2) at the 11th Session of the FAO Conference mentioned the important role played by certain plants in human nutrition. The number of known vegetable species exceeds 250,000 but man during the course of his history has used only 3,000 to feed himself. This number has become progressively reduced during the course of the centuries because the agronomist and the breeder have concentrated their efforts only on the most interesting ones. At present only 300 food plants are cultivated at a commercial level. Of these, twelve species alone produce 90 percent of the available world food supply. These species are rice, wheat, maize, sugar cane, sugar beet, potato, sweet potato, manioc, common bean, soya bean, coconut, and banana.

3. In this list the predominance of plants providing many carbohydrates (starch and sugars) is noticeable. Rice, for example, can be considered the most important food. Sixty percent of the inhabitants of the world obtain 80 percent of their daily

(1) Mangelsdorf, P.C., Biology, Food and People, Economic Botany 15-4, 279-288 Cambridge (Mass.) (1961)

(2) Rockefeller, John D., People, Food and the Well Being of Mankind, FAO, Rome (1961)

intake of calories from this crop. It is estimated that more than 30% of human energy in the world today is obtained from this one plant.

4. Undernourishment and malnutrition together affect one-third to one-half of the peoples of the world, the majority of whom live in the tropical and sub-tropical areas. The Nutrition Committee for South East Asia has pointed out that to combat the deficiency of proteins, vitamins and minerals in many rice eating countries, it will be necessary to step up the production and consumption of fruit, vegetables, and grain legumes. In a recent FAO study it was estimated that the population of the region will increase by 50% over the next 20 years and the production of fruit, vegetables, and grain legumes will need to be almost trebled by 1980 if reasonable nutritional requirements are to be met.

5. Typical diets in the tropics and in most low income nations, particularly in the highly populated regions are predominantly starchy in composition. Production of such crops as cassava, yams, cocoyams, plantains, rice, and maize, usually requires less land and less labour per 1000 calories than other foods. These crops, when eaten, fill the stomach but are very deficient in ~~protein~~, fats, minerals and proteins that are essential for good nutrition and good health.

6. Fruits and vegetables are good sources of vitamins and minerals, and legumes and nuts also supply proteins. Many nuts, for example, have a high oil and protein content, making them valuable human and animal foods. Vegetables belonging to the legume family such as beans and peas, are rich in proteins as well as carbohydrates. Fruits such as the avocado and olive are rich in oil. It will be evident that fruits and vegetables play a significant and often essential role in human nutrition and all methods should be used to encourage their further cultivation and consumption.

(a) PLACE OF FRUIT AND VEGETABLES IN THE CROPPING SYSTEMS

(i) Vegetables

7. An evaluation of the importance of vegetables in the tropical diets is difficult to make since statistics in most developing countries are notoriously inaccurate and year to year variations in the crops are large. It is therefore not possible to obtain figures for the amount used for home consumption from data on local and international trade.

8. Vegetable production in developing countries should increase substantially in the near future if standards of nutrition are to be improved and the increase in demand resulting from the rising tide of population and higher monetary incomes is to be met. The increase in production must be selective and directed especially towards horticultural products that provide nutrients now in short supply such as protein and vitamin A.

9. In many of the less developed countries, monoculture and shifting cultivation are frequent pradtices and they are among the main factors responsible for the lack of a satisfactory standard of agriculture. The introduction of vegetable crops into the cropping system would be advantageous for soil conservation, maintenance of soil fertility particularly through the introduction of legumes in the rotation. Such steps should lead to a more stable economy and a higher standard of living. Some tropical countries offer good examples of intensive multicropping systems.

10. In Taiwan, for example, rice or sugar cane are planted in rotation with vegetables. Many kinds of vegetables are cultivated as cash crops: carrots, cauliflower, spinach, lettuce, etc. in the cold season, while in the summer season egg plant, pepper, okra, cucumber, melon, etc., are commonly planted in the rice fields. In Central Taiwan, rice is grown continuously in the same field but either a green manure crop (such as Sesbania) or a summer vegetable such as melon is grown between the 1st and 2nd crop of rice. With the vegetable crop grown during the winter season, four crops are obtained per annum in this area. In non-irrigated districts a yearly single crop of rice is grown during the rainy season and followed by sweet potato, peanut, vegetables or green manure.

11. In Sierra Leone most of the vegetable cultivation takes place in the dry season along the sides of the streams. At this time of the year, streams can be channeled and diverted to provide irrigation water for vegetable crops such as: beans, lettuce, radish, kale, tomato, egg plant, shallot, etc. During the wet season the streams become small rivers and the dry season gardens are virtually abandoned after the final harvesting of the crops in May or June. The "wet season gardens" are then reconstituted on terraces sited on the upland, preferably below or near the dwelling houses. The range of crops grown during the rainy season, from May to October, is much less than that of the dry season.

12. In many tropical countries it should be possible to adapt such practices to local conditions in order to introduce vegetables crops into the short-term rotation systems. The development of school and community gardens, and home gardens in the compound or in the back yards, should be encouraged to teach new methods of food production and use in order to increase the yield and local consumption of more and better vegetables.

(ii) Fruits

13. There appear to be two main ways in which tree food crops may be fitted into cropping systems either - i) for subsistance or ii) on a plantation scale for cash. From a nutritional viewpoint both methods have their place. In both, the application of more advanced horticultural techniques, better varieties, fertilizers, irrigation, and pest and disease control will bring increases in quantity and quality of the crops. In the less developed countries large scale cultivation of fruit trees is not common for these are generally treated as "back yard" crops, being planted near and around the houses. It would be difficult to talk of orchard management since fruit trees are not planted in orchards, with a few exceptions such as bananas, pineapples, citrus, when grown for export.

14. In the humid tropics the growing of fruit tree crops on a modern intensive scale may encounter certain difficulties. In many cases where soils are exposed and cleared of their native vegetation, a general deterioration in fertility ensues depending on rainfall, soil type, and nature and duration of the cropping. Methods of preserving fertility are not so well established for tropical soils as for those in Northern latitudes, at least for some of the tropical crops that are being grown commercially on an increasing scale. This increase means a fundamental change in the traditional methods of so many developing countries, from shifting cultivation to permanent cropping. Apart from the technical aspects of cultivation of such soils, this change-over is often hindered by the system of land tenure for the land is often held communally and therefore offers little incentive to the individual farmer to improve it. Again, the small size and fragmented nature of the family holding may prevent any efficient mechanisation of cultivation, control of pests and diseases, etc. When these factors are overcome the uprooting of the dense vegetation is often a very costly and difficult task. However, that this is

possible is illustrated by the successful plantations of economic crops, i.e. cocoa and coffee.

15. In the more arid areas increase of production of plantation crops is primarily dependent on suitable water sources. While there has been tremendous development in irrigation schemes in many countries in the last decades, still much remains to be done. On the other hand, irrigation introduces the possibility of salt accumulation and waterlogging, and skill and experience is required by farmers before irrigation can be utilised successfully. Fortunately, plants show a marked difference in tolerance to salinity. Of the fruit crops the date palm is most resistant, pomegranates, figs, olives and grapes form an intermediate group, while citrus and avocado are very susceptible. However, when handled judiciously, irrigation is probably the largest single factor that will influence food production in vast areas of the world. It has been found in Israel, for example, that the introduction of water can reduce the land required by a farmer and his family by a factor of 10.

(b) NUTRITIONAL OBJECTIVES FOR HORTICULTURE IN THE TROPICS

16. The primary aim of agriculture should be to produce enough food to satisfy not only quantitative requirements, or calories, but also enough of the foods rich in proteins, vitamins and minerals to ensure good health for all the people.

17. Whether it is rice or burghul, potatoes or cassava, kous kous or mealie meal, plantain or yams, staple foods are primarily a starch that supplies energy or calories and, in addition, widely varying but always inadequate amounts of the proteins for growth, and varying amounts of the vitamins and minerals needed to regulate delicate physiological mechanisms.

18. Whether diets meet human requirements for normal growth and development and the maintenance of good health depends very largely on the composition of the sauce or other accompaniment that is eaten with the staple food. The nutrients in the foods that accompany the basic dish depend in turn, to a large extent, on the horticulture practised in the country. In earlier times, green leaves, fruits and vegetables, roots and condiments were foraged in the fields and woods or grown near the house. Today, with the rapid increase of population, and the use of more and more land for cash and staple crops, wild leaves, roots and fruits can no longer be foraged in the needed amounts, nor can families who have migrated to industrialized areas grow them at home. Unaware of the causes or the results of malnutrition, families do not spend wages or the income from cash crops on foods that supplement the starchy diet. Instead, sweet biscuits, sugar, soft drinks and tea often replace the vegetables, fruits and other foods of high nutritive values.

19. Much is known about the nutrients supplied by the major basic foods. Their protein content ranges from less than 2% in cassava, yams, plantains, bananas, and sweet potatoes to 10% or more in wheat, oats, millet and sorghum. The quality of the protein from any one vegetable source is, however, inadequate for biological purposes. If the accompaniment of the starchy food contains an animal protein - meat, dried or fresh fish, milk in any form, or eggs, this high quality protein will supplement the vegetable protein.

20. Many millions of families do not use animal foods regularly because they

cannot afford them. In both Africa and Asia the production of animal protein foods cannot be increased to meet the needs of the population for many years to come. The export of a crop such as banana, may indirectly promote better nutrition of the exporting country by enabling that country to buy other foodstuffs that provide nutrients in short supply. This, however, is often not the case and it has been found in certain countries in Africa that the more land that was cultivated, the greater was the protein shortage. Two reasons are advanced for this:

(i) As the bush is cleared for cropping so bush meat is driven away, and so the farmers' reserve of first-class protein is diminished.

(ii) Instead of the new crops having a high protein content, cocoa or some other cash crop is grown that is not consumed locally. However, in every country exporting fruits, large quantities of culls that are not necessarily inferior from a nutritional point of view are usually available for consumption at very cheap rates to the local populations.

21. Post war advances in food chemistry have provided an important key to the solution of the protein problem. Knowledge of the wide variation in the distribution of amino acids in proteins from different plant sources makes it possible to combine these plant proteins to supply the amino acids essential for body growth and repair. A wide variety of pulses and peanuts grow readily in tropical areas, provide twenty to thirty-eight grams of protein per hundred grams when dried, and are good sources of the B vitamins. It is both necessary and possible to increase greatly the supplies of pulses and nuts available in tropical countries, and to promote these varieties that contain the higher levels of proteins.

Vitamins

22. The B vitamin content of the starchy staple foods varies widely. For example, undermilled and parboiled rice provide protection against beri beri because the thiamin occurring in the rice grain is conserved, whereas, in polishing, rice loses not only much of the thiamin but other nutrients as well. As a result, the poor man and his family, whose diet consists largely of polished rice, are the principal victims of beri beri while families who can afford generous portions of gram curry and other vegetables rich in thiamin with their rice, rarely suffer from beri beri.

23. In the Near East, peasants whose diets consist largely of maize tend to develop pellagra because maize is low in niacin and the protein is inferior. Those who can afford to eat pulses and other vegetables, or a skim milk cheese with their maize bread, do not develop pellagra.

24. Vitamin A is not found in starchy foods, with the exception of yellow maize and yellow sweet potatoes. Vitamic C does not occur in cereals, and only to a very limited extent in cooked roots and tubers. These vitamins must therefore come from vegetables and fruits eaten at home or in the fields or bush.

25. Green leaves, green and red peppers, orange colored fruits and vegetables and red palm oil are all excellent sources of carotene or pro-vitamin A. Green leaves also supply small amounts of high quality proteins that help to supplement the protein in starchy foods. In West Africa and other areas where red palm oil is used in sauces, and in areas where wild greens or the leaves of cassava, sweet potatoes, beets, spinach, amaranth or other plants are regular items of diet, vitamin A deficiency does not occur.

26. Eye disease resulting from vitamin A deficiency is frequently reported in North Africa, the Middle East, Northern Nigeria, many parts of India, the Philippines and areas in the Highlands of Central and East Africa where red palm oil is not available. It is possible that lack of vitamin A is second only to protein deficiency as a cause of nutritional disease, and that the two frequently occur together in children living in tropical countries.

27. Without fruits and vegetables diets are not satisfactory. For example, a school meal is normally designed to meet one-third of the child's daily nutrient allowance. In areas, where protein foods are scarce and expensive, or where fruits and vegetables are not widely used, it may be necessary for the school meal to exceed one-third rule in some nutrients in order to make up deficits in family diets. School and community gardens, and poultry raising projects make this possible at very little extra cost.

(c) IMPORTANT FRUIT SPECIES FOR THE TROPICAL AND SUB-TROPICAL AREAS

28. It may be of interest to follow in more detail a few examples of the dependence of the less developed areas of the world on fruits as important sources of essential nutrients. The prime importance of increased production and use of pulses, nuts and vegetables of all kinds has been mentioned above.

29. The mango (Mangifera indica L.) is said to occupy the largest area of any fruit crop in the tropics. India is its real commercial home, and nearly 60% of the total acreage of all fruit crops in that country is planted in mangoes. It has a tremendous local consumption there and has an important place in the nutrition of the people. The mango is an important source of vitamin A, while the vitamin C content of most common varieties is as high as or higher than in citrus fruits.

30. From the horticultural standpoint the mango has the great advantage that it is, under the right climatic conditions, a hardy tree requiring little maintenance and giving profuse yields. It is therefore a tree which is ideal in the compound or backyard as a ready source of food and shade. In many tropical countries nearly all the mangoes grown are of seedling nature, and taste, according to Fairchild, of "a ball of tow soaked in turpentine and molasses" (3). However, the "inferior" varieties are often in great demand locally for their thin sweet juice, the so-called "sucking" varieties. It is only by the propagation of known varieties by budding or grafting or by selection of seeds of polyembryonic origins that true-to-type varieties of superior and uniform quality will be obtained. When these measures are taken, not only will the local consumption be increased but the possibility of exports will be enlarged.

31. The two major fruit crops of the tropics and subtropics both in total production and amount exported are the banana and citrus. The banana (Musa spp.) as well as being the most exported of all the fruits is also the crop consumed in large amounts at home. In Uganda, for example, it has been reported that the daily consumption is 3,9lbs per head (4). This includes the starchy cooking form known as plantain. Bananas of all varieties are very low in protein content. In countries where bananas are the major staple of the diet, protein deficiencies result in high rates of infant and child mortality unless supplemented with protein rich animal foods or legumes.

(3) Fairchild, D. On the introduction of the mango into Florida, Florida Mango Forum, Mango Studies 12. (1951)

(4) Simmonds, N.W. Bananas, Longmans, London, (1959)

32. The subtropical areas of the world are by far the greatest exporters of citrus fruits, while the tropical areas produce large quantities for local and home consumption. For a variety of reasons countries with subtropical climates have been able to develop the export of citrus on a large scale - in the tropics the quality of oranges at least is usually not so high; the warm tropical climate producing a fruit low in acidity with an insipid taste, also the characteristic orange colour does not develop well unless there are somewhat lower temperatures during ripening. The behaviour of grapefruit is different - these fruits produced under tropical conditions like Nigeria or Trinidad generally develop a very fine flavour. The lime is the most prominent acid citrus crop in the tropics - and takes the place of the lemon common in the subtropics, while the mandarin also succeeds in the tropics with high rainfall conditions.

33. Citrus fruits are a rich source of vitamin C and also a good source of vitamin A. In some areas where vitamin C shortage is widespread, the deficiency is not so much a matter of economics as of education. The fruits are usually available and in cheap supply in season, but ignorance of nutrition and prejudices often associated with taboos exist against the eating of fruit. For example, in West Africa, the sweetness of a fruit is associated with effeminacy. In such cases increased production would not be followed by increased consumption unless accompanied by considerable education and propaganda.

34. Another crop in which interest has been shown by nutritionists in recent years is the guava (Psidium guajava L.) mainly because of its high vitamin C content, some strains having as much as 3 to 4 times the amount found in citrus juices. The guava is the most important species of fruit in the Myrtaceae family, and the only one of that family that is grown to any extent in plantation form. In most Central and South American countries it is not, however, grown in this matter, but large quantities of fruits are obtained from back-yard trees. It is not widely known in international trade, but in countries where it is grown the fruit and its products are an important source of vitamin C during the short guava season and in some areas in processed form. Considerable work should be done to improve the production and one of the best ways is by budding or grafting known cultivars on seedlings, as has been done to a large extent in South Africa.

35. The avocado (Persea gratissima Gaertn) is a fruit which, in order of importance, comes after citrus, bananas, pineapples and mangoes in total acreage and export of the tropical fruit crops. In its native tropical America it is an exceedingly important food crop. Unlike most fruits except the olive, its oil content ranges from 11 to 25%, both variety and 'race' determining largely the fat content, the West Indian race is the lowest, the Guatemalan intermediate and the Mexican the highest. The avocado is a good source of several vitamins, including vitamin B complex and of vitamin A and E, but low in vitamin C. It is especially valuable as a source of fat in areas where the coconut does not succeed. It is an important food for many inhabitants of Mexico and other Central American countries. In the last century, large areas of avocados have been planted outside its native tropical America - in South Africa, Australia, California, Florida, southern Spain and Chile. Because of its special qualities - as a salad fruit of high nutritive value and the fact that it stands shipment better than many other tropical fruits, the avocado seems destined to play an ever increasing part both in local consumption and as a means of increasing foreign exchange for the developing countries.

36. The Palm family (Palmaceae) has two important horticultural tree crops which play a major part in human nutrition in two very different climatic areas of the world - the coconut (Cocos nucifera L.) which grows throughout the humid tropics and the date (Phoenix dactylifera L.) which is found wild from Iran westwards to North and West Africa in arid desert-like areas. For successful fruiting and maturing of a normal crop an abundant supply of underground or irrigation water all the year round is essential. It is not generally realised that the water requirement

of date palms is higher than that of citrus, although the quality of water is of much less importance, i.e. the tree is more tolerant of salinity than most other species.

37. Dates are well known as a rich source of carbohydrates, containing as much as 70% (mainly in the form of sugars) and they also contain a moderate amount of the B-vitamins. According to Nicholls (5) "a Bedouin who takes ½ lb of dates and a pint of fermented camel's milk is making an adequate and well balanced meal of about 900 calories". In most desert areas of the world the date palm is the only crop which succeeds under extreme conditions. World production is close to 2 million tons of fruit produced from about 85 million adult date palms.

38. The most important member economically of the Palm family is probably the coconut palm, which in India is said to have 999 uses. Like most nuts its nutritional value lies primarily in its high oil and protein content. Copra, which is the main product from the coconut, is the dried white kernel which serves primarily for the manufacture of coconut oil. This oil is used as a food, i.e. in the manufacture of margarine and locally as a cooking fat. A small amount of Copra is used in the production of desiccated coconut.

39. Brief reference must be made to a large number of forest trees, shrubs and herbs which supplement the diet of both adults and children in vast areas of the tropics. These are too numerous to mention in any detail but for illustration the following species must be cited as they play an important role in human nutrition: pineapple, litchi, cashew-nut, papaya, breadfruit, annonas, passion fruit, etc.

(d) CONCLUSIONS

40. In conclusion, it is hoped that the above examples illustrate the important part which fruit and vegetable crops can play in human nutrition. In many parts of the world these foods are growing wild in the bush or forest or are raised from seedlings and planted around the compound or homestead. Others have achieved permanent plantation status and their cultivation is based on the application of modern horticultural practices. The possibilities of improvement in yield and quality of all these crops remains immense and their potentialities for providing better nutrition and better health for the ever-growing population of the world are as yet almost unrealised.

41. The same effort, skill and devotion should now be applied to the selection, breeding and cultivation of tropical and subtropical crops as have been applied to the more northern fruits and vegetables. Then their potentialities for providing scarce nutrients and delighting the palate of the world may, perhaps, be greater than those of the north.

42. The imperative need to include more fruits, vegetables, legumes and nuts in the diets of many populations of tropical regions is becoming generally recognized. Programs of education and training in nutrition combined with school and community gardening have been undertaken by the governments of more than forty countries with assistance from FAO, UNICEF and other international and bilateral agencies. The production, preparation and preservation of fruits and vegetables is being taught in many countries through programs of home economics extension and community development. The cooperation of horticulturists with special skills in teaching and demonstrating, and a knowledge of tropical and subtropical fruit and vegetable production is essential to the successful expansion of these programs throughout the developing countries.

(5) Nicholls, L., Sinclair, H.M. and Jeliffe, D.B. "Tropical Nutrition and Dietetics" Baillière, Tindall and Cox, London (1961)

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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: C.4.3

Food and Agriculture Organization

THE PLACE OF FRUIT AND VEGETABLE CROPS IN FOOD PRODUCTION IN THE LESS DEVELOPED AREAS OF THE WORLD

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THE PLACE OF FRUIT AND VEGETABLE CROPS IN FOOD PRODUCTION IN THE LESS DEVELOPED AREAS OF THE WORLD

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The diets of the populations of many tropical countries are predominantly starchy in composition because they consist largely of cassava, yams, bananas, plantains, rice, etc. and are lacking in the proteins, vitamins and minerals necessary for normal growth, good health and working efficiency. This is characteristic of most low income nations in the world, above all in the highly populated regions.

The importance of fruits and vegetables in the diet does not lie in their contribution of carbohydrates or fats, but rather as rich sources of the vitamins, mineral salts and, in the case of legumes and nuts, the proteins that are so indispensable for human health. All methods should, therefore, be used to encourage expansion of their cultivation and consumption.

In many of the less developed countries, especially in Africa, monoculture and shifting cultivation are frequent practices. The introduction of vegetables into the cropping system of these countries would also be advantageous for soil conservation and the maintenance of soil fertility through introduction of legumes. These factors would help to develop a more stable economy and a higher standard of living.

Intensive cropping systems which introduce vegetable crops in the rotation would provide tropical countries with the possibility of higher returns and better production of food.

Special consideration is given to the main fruit species of importance to nutrition in the developing countries, such as mango, banana, citrus, guava, avocado, date palm, coconut, etc.

There is hope that programs of education and training in nutrition which are multiplying rapidly in the developing countries, will bring to the fore the important role of fruit and vegetables in the diet of the populations of tropical regions and will lead to improvement in the production and consumption of these horticultural crops.

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Point de l'ordre du jour : C.4.1

Sénégal

RECHERCHES DE PHYSIOLOGIE VEGETALE SUR LE PROBLEME DE LA RESISTANCE DE L'ARACHIDE A LA SECHERESSE

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COMMUNICATION C-4-1 - REPUBLIQUE du SENEGAL

RECHERCHES de PHYSIOLOGIE VEGETALE SUR le PROBLEME de la RESISTANCE de l'ARACHIDE A LA SECHERESSE

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1. INTRODUCTION

a) Pour la région Nord du Sénégal, la faible pluviosité, (416 mm de pluie à Louga), constitue un des principaux facteurs limitatifs des rendements. L'étude de la résistance de l'arachide à la sécheresse a donc une incidence pratique considérable.

b) La résistance d'une plante à la sécheresse dépend de très nombreux facteurs que l'on peut schématiser ainsi.

i)	Facteurs morphologiques ⟷	Facteurs physiologiques →	Action des facteurs
ii)	Système radiculaire bien développé par rapport à la partie aérienne	Pression osmotique élevée des racines →	Augmentation de l'absorption de l'eau
iii)	Feuilles petites à cubicule épaisse, stomates étroits	Fermeture rapide des stomates en condition de dessiccation →	Diminution de la transpiration
iv)	Feuilles épaisses - tissus spécialisés dans l'accumulation de l'eau	Force de succion élevée des cellules-Teneur en eau liée élevée →	Augmentation des réserves en eau des tissus

v) Croissance relativement peu diminuée en conditions de sécheresse

Viscosité et élasticité du protoplasme → résistance à la chaleur et à la déshydratation → Augmentation des capacités de ré istance protoplasmique

Processus de synthèse élevés par rapport aux processus d'hydrol;ses

c) Les recherches ont d'abord précisé la sensibilité de l'arachide à la sécheresse pour les diverses étapes de sa croissance; on a ensuite tenté d'augmenter la résistance de la plante à la sécheresse,et enfin on a réalisé des recherches préliminaires pour établir des tests physiologiques de la résistance à la sécheresse.

2. STADES de SENSIBILITE A LA SECHERESSE

a) Ces recherches étudient l'influence d'une variation expérimentale de l'eau apportée à l'arachide à diverses époq es de sa croissance. Les expériences ont été réalisées dans deux conditions

i) cultures au champ où le nombre élevé de plante permet une estimation précise de l'influence des traitements sur les rendements.

ii) cultures en vases de végétation où l'on contrôle plus rigoureusement les facteurs externes.

b) Cultures au champ

i) ces essais sont réalisés par la méthode des "parcelles temporairement couvertes". Une toiture amovible peut couvrir la totalité d'une parcelle et ainsi arrêter une partie des pluies naturelles. On peut aussi augmenter la pluviosité par un arrosage artificiel.

ii) On ne donnera ici que les résultats d'une de ces expériences. Le tableau 1 montre que si l'arrêt des pluies a une nette influence sur la croissance au moment de la floraison intense, mais non plus tard, il a par contre une action marquée sur les rendements à toutes les époques étudiées.

c) Cultures en vases de végétation

i) les nombreuses expériences réalisées, confirment en les précisant les résultats obtenus au champ.

ii) Dans une de ces expériences, des traitements de sécheresse ont été appliqués, à 4 stades de la vie de la plante, en comparaison avec un témoin maintenu à la capacité au champ.

a - du 10ème au 30ème jour, c'est-à-dire de la levée à la première fleur,
b - du 30ème au 50ème jour, c'est-à-dire au début de la floraison,
c - du 50ème au 80ème jour, c'est-à-dire pendant le palier de forte floraison, jusqu'à la fin de la floraison dite "utile" (40 jours avant la récolte),
d - du 80ème au 120ème jour, c'est-à-dire pendant la période de fructification et maturation jusqu'à la récolte.

iii) les traitements de sécheresse consistaient à laisser le sol se dessécher jusqu'au point de flétrissement permanent (pF = 4,2) et à le ramener ensuite à la capacité au champ.

iv) en ce qui concerne le rendement en gousses (en % du témoin) les objets se classent ainsi : a 82 - b 78 - d 73 - c 54.

v) d'où les conclusions suivantes :

a - toutes les périodes du cycle végétatif sont sensibles à la sécheresse qui diminue de façon importante les rendements (au moins 20 %).
b - la sécheresse la plus dommageable est celle qui intervient du 50ème au 80ème jour, soit pendant la forte floraison. Dans ce cas, elle entraîne une baisse de rendement d'environ 50 %.

3. AUGMENTATION de la RESISTANCE A LA SECHERESSE

a) On peut augmenter la résistance de la plante à la sécheresse en économisant l'eau du sol ou en modifiant le métabolisme de la plante. Les deux méthodes ont été utilisées.

b) On a étudié l'influence des coques d'arachide.

i) Les résultats sont particulièrement intéressants dans les zones à pluviosité faible. En voici un exemple pris dans la région de Tivaouane en 1961 :

Témoin	1160 kg de gousses à l'hectare
10 tonnes coques broyées	1480 kg
10 tonnes coques grossières	1180 kg

ii) dans la zone-nord, un enfouissement de coques finement broyées peut être considéré comme une assurance contre les risques de sécheresse.

c)i) Certains auteurs ont obtenu une augmentation de la résistance à la sécheresse par trempage des graines suivi de deshydratation, ou par trempage dans des solutions d'oligoéléments ou de calcium

ii) des nombreux essais réalisés, nous en voyons les résultats donnés dans le tableau 2.

iii) deux effets sont particulièrement nets :

a - un effet dépressif de la sécheresse sur le rendement.
b - un effet dépressif de la sécheresse sur le nombre de pieds récoltés qui ne se manifeste nettement que pour les témoins.

iv) on peut donc dire que le traitement des graines a augmenté la résistance à la sécheresse, puisque lorsque les plantes sont privées d'eau pendant la période de pleine floraison, elles meurent en plus grand nombre si les graines n'ont pas été traitées.

4. TESTS PHYSIOLOGIQUES

a) Les mesures physiologiques sont destinées d'une part à mettre en évidence les manifestations précoces de la résistance à la sécheresse et d'autre part de déterminer la nature même de cette résistance. Ces deux sources de renseignements doivent permettre la mise au point de tests pour sélectionner, le plus précocement possible, des lignées ou des pieds résistants, multipliés par la suite.

b) Ces recherches préliminaires ont été réalisées sur quatre variétés d'arachide dont on avait au préalable évalué la résistance à la sécheresse dans des essais comparatifs.

c) Le test d'Arland (mesure de la transpiration relative) et le test de Coffman (résistance à la chaleur), n'ont montré aucune relation avec la résistance à la sécheresse. Par contre, la mesure du déficit en eau, de la résistance à la dessication et de la viscosité protoplasmique (méthode plasmolytique) permettent une bonne classification des variétés selon leur résistance à la sécheresse. Ceci indique que la résistance de l'arachide serait liée à la résistance à la déshydratation des tissus, plus tôt qu'à la résistance à la chaleur. Ces études doivent être poursuivies avant de donner des conclusions nettes.

TABLEAU 1

Influence de l'arrêt des pluies
à diverses époques du cycle de culture

	Pas d'arrêt (1) Témoin	Arrêt du 35 au 60ème jour (forte floraison(1)	Arrêt du 60 au 85ème jour (2)	Arrêt du 85 au 100ème jour (3)
Croissance (longueur en cm des rameaux cotylédonnaires	51,3 (100)	42,2** (86)	50,8 (99)	54,0 (105)
Rendements (Kg gousses/ha)	924 (100)	656** (71)	664** (71)	777 (84)

Entre parenthèses, pourcentage du témoin
* significatif à 0,05
** " " 0,01

(1) pluie totale : 407,5 mm
(2) " enlevée : 165,5 mm
(3) " " : 95,0 mm
(4) " " : 65,5 mm

TABLEAU 2

Influence de B et Ca sur
la résistance à la sécheresse

	T				B				Ca			
	N		S		N		S		N		S	
	(-)	E	(-)	E	(-)	E	(-)	E	(-)	E	(-)	E
Nbre de pieds récoltés par parcelle	80,5	81,0	52,7	56,8	79,7	75,5	71,2	68,0	79,5	88,2	71,5	68,0
Rendements gousses par pied (g)	14,0	13,7	8,8	10,9	10,0	11,0	8,1	8,5	10,7	16,0	9,7	10,5

T = Témoin B = trempage dans borate de soude 1°/°° Ca = trempage dans chlorure de calcium 1 %

N = pluviosité normale

S = traitement de sécheresse - 131 mm de pluie ont été enlevés pendant la période de pleine floraison.

(-) sans engrais E = 40 kg de sulfate d'ammoniaque, 60 kg de phosphate bicalcique et 20 kg de chlorure de potasse à l'hectare

Le manque d'action de l'engrais sur les rendements n'a rien de surprenant, étant donné la bonne fertilité des sols de la station.

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Senegal

VEGETABLE-PHYSIOLOGICAL RESEARCH ON THE PROBLEM OF THE RESISTANCE TO DROUGHT OF THE GROUND-NUT

By Dr. P. PREVOT,
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Bambey

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VEGETABLE-PHYSIOLOGICAL RESEARCH ON THE PROBLEM OF THE RESISTANCE TO DROUGHT OF THE GROUND-NUT

By
Dr. P.Prevot, Agrégé of the University of Liége, Director of Agronomic Research at the I.R.H.O.
- and -
R.Bilfaz, Agronomical Engineer, I.R.H.O. Section of the C.R.A., Bambey.

1 (a) The importance of drought to the yields in Senegal is shown.

(b) A tabular summary is given of the various morphological and physiological factors which govern the resistance of the plant to drought.

2 (a) The research of the I.R.H.O. during the initial stage is aimed at determining the stages of growth at which the plant is particularly susceptible to drought. For this purpose, experiments have been carried out in pots containing vegetation and also in plots of ground temporarily covered over for the purpose.

(b) These experiments have shown that the ground-nut is susceptible to drought at all stages of its growth, but most particularly at the stage during which it is in full bloom.

(i) The successive signs of greater resistance to drought are: more active growth, fuller flowering, earlier and more copious fructification, and finally, higher yields.

3 (a) During the second stage of this work, the effect of various methods of cultivation on the economy of ground water is studied. It has been shown in particular that the incorporation in the soil of finely ground shells (of nuts) may be regarded as an assurance against the risk of drought in North Senegal.

(b) Treatment of the seeds by a solution of trace element and calcium has been studied. It was noted especially that soaking the seeds in solutions of chloride of calcium increased the resistance of the plant to drought.

4 (a) Finally, the last stage of these studies has just begun. It comprises the finding of physiological tests in relationship to the resistance of the plant to drought, and which would permit of the orientation and improvement of the work of selection.

(b) The most interesting tests appear to be:

(i) measurement of growth under standardised conditions;

(ii) water content of the tissues;

(iii) resistance to dessication;

(iv) measurement of protoplasmic viscosity.

5. These studies call for amplification. The results obtained show that there is a possibility of their making a useful contribution to the problem of the resistance of the ground-nut to drought.

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CONFÉRENCE DES NATIONS UNIES
SUR L'APPLICATION DE LA SCIENCE ET DE LA TECHNIQUE
DANS L'INTÉRÊT DES RÉGIONS PEU DÉVELOPPÉES

Point de l'ordre du jour : C.5.1

Sénégal

CONSERVATION DES VIRUS VACCINS PAR LYOPHILISATION (CAS PARTICULIER DE LA LYOPHILISATION SOUS CONDITIONS TROPICALES)

Par Yves GILBERT,
Docteur Vétérinaire,
Chef du Service de Virologie du Laboratoire National
de Recherches vétérinaires de Dakar, Sénégal

Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

NOTES

1. Les mémoires choisis pour être présentés en séance générale pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

2. Les mémoires choisis pour être présentés en séance spéciale pourront être obtenus à la Conférence dans l'une seulement de ces langues officielles.

3. Les résumés qui ont été rédigés pour tous les mémoires par les auteurs de ceux-ci pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

4. Préalablement à la Conférence, les mémoires et les résumés ne feront pas l'objet d'une distribution générale mais d'un tirage restreint destiné aux délégations des gouvernements et autres participants officiels. La publication et la distribution générale des actes de la Conférence s'effectueront conformément aux règles et pratiques agréées par le Comité des publications des Nations Unies.

CONSERVATION DES VIRUS VACCINS PAR LYOPHILISATION
(CAS PARTICULIER DE LA LYOPHILISATION SOUS CONDITIONS TROPICALES)

Yves GILBERT, docteur vétérinaire
chef du service de virologie du Laboratoire national de recherches vétérinaires de Dakar, (Sénégal)

Avant propos :

La lutte contre les maladies épizootiques du bétail en régions tropicales recourt de plus en plus à l'utilisation de virus vaccins, auxquels on reconnaît de multiples avantages sur les plans de l'efficacité, de la durée de l'immunité conférée et surtout du prix de revient.

Ces produits biologiques sont particulièrement fragiles, et la durée de conservation de leur activité serait d'une brièveté incompatible avec les délais de transport et d'utilisation s'il n'était fait appel à la méthode de cryodessiccation (lyophilisation) pour assurer leur stabilisation.

Mais la réalisation de la cryodessiccation, parfaitement au point dans les régions tempérées, se heurte dans la zone intertropicale à des difficultés liées à l'ambiance.

En effet, cette zone est caractérisée essentiellement par une température moyenne élevée (les maxima dépassent souvent 40°C) et en certaines saisons, une très forte hygrométrie.

A ces conditions climatiques défavorables s'ajoutent les effets du sous équipement que connaissent nombre de territoires.

Le présent mémoire résume des observations récueillies pendant plusieurs années de pratique, fait connaître les difficultés rencontrées et les solutions possibles.

I - Difficultés rencontrées.

Lyophiliser un produit, c'est, après l'avoir congelé, en extrair l'eau par sublimation sous vide. Il importe donc de disposer d'une sourc de froid, des moyens de produire et entretenir le vide, et d'appliquer convenablement ces procédés à la réalisation des opérations successives de congélation et dessiccation afin de respecter au maximum les qualités essentielles du produit. Nous envisageons donc tour à tour les difficult rencontrées sous conditions tropicales dans la production du froid et du vide, puis au cours de l'opération elle-même.

a) Le froid.

Celui-ci peut être produit économiquement par les seules machine frigorifiques. La glace carbonique n'est pas, sauf exception, fabriquée sur place, et sa préparation à partir du gaz carbonique liquide revient un prix prohibitif. Les gaz liquéfiés (air et azote liquides) sont encor d'un emploi restreint et coûteux, applicable seulement aux travaux de recherche, non à une production à l'échelle semi industrielle.

Sous conditions tropicales, les machines frigorifiques à compres seur fonctionnent avec un mauvais rendement en raison de la température des fluides de refroidissement air ou eau. Celle-ci en particulier attei couramment 30 à 35°C et l'on observe sur le circuit de refoulement du fluide frigorigène des pressions considérables. La production en frigori subit une baisse sensible.

Les apports de chaleur par rayonnement et conduction sont accrus par l'élévation de la température ambiante, et les performances des appa reils sont nettement inférieures à celles enregistrées en climats tempér

Il résulte de ce fait une fatigue générale de l'appareillage (compresseur surtout) se manifestant par de fréquents incidents que comp quent les difficultés à se procurer des pièces de rechange et la rareté des spécialistes qualifiés dans la technique des basses températures.

b) Le vide.

Le problème de la réalisation et de l'entretien du vide est doub Il comporte en effet l'élimination :

a) des gaz permanents (air en particulier) emplissant l'enceinte où s'effectue la lyophilisation, ou pouvant y pénétrer par des défauts d'ét chéité ;

b) de la vapeur d'eau produite par la sublimation de la glace et do l'évacuation ne peut être assurée par les pompes.

En ce qui concerne les gaz permanents, la production du vide ne pose pas sous conditions tropicales de problèmes particuliers.

L'élimination de la vapeur d'eau est normalement assurée par une paroi froide, jouant le rôle de pompe à grand débit, car les desséchants chimiques sont à peu près abandonnés.

L'efficacité de ce piège dépend en grande partie de sa température. Plus celle-ci est basse, plus le transfert de la vapeur émise par le produit maintenu à une température déterminée est rapide. Lorsqu'on dessèche un produit pour lequel la sublimation peut s'effectuer à température relativement élevée (-15, -20°C) une vitesse de dessiccation satisfaisante peut être obtenue avec un piège à -40°C. Mais s'il s'agit de matériels à bas point eutectique (-25 à -30°C), et certains produits à dessécher sous conditions tropicales offrent cette particularité, il est nécessaire de disposer d'une paroi froide à très basse température (-60°C par exemple), pour maintenir une pression différentielle suffisante et obtenir la dessiccation dans un temps raisonnable.

Compte tenu des conditions adverses de production du froid, les appareils actuellement construits permettent d'obtenir ici une température au niveau du piège supérieure de 5 à 10°C à celle annoncée pour les régions tempérées. La durée de la dessiccation en est sensiblement prolongée.

L'évaporateur à détente directe semble le moins affecté par les conditions tropicales. Des températures basses peuvent être atteintes par l'emploi d'un seul étage de compression, mais on ne dispose pas d'un volant de froid, comme dans le cas du système à détente indirecte, où l'évaporateur du groupe frigorifique refroidit une masse de fluide (alcool par exemple). Il est alors nécessaire de recourir à des étages multiples de compression pour obtenir de basses températures. Le fluide refroidi peut aussi être utilisé pour la congélation rapide des produits, et la limitation du réchauffement du matériel en fin de dessiccation. Ce dernier résultat n'est acquis qu'au prix du réchauffement du fluide et par conséquent du piège. Il serait préférable d'alimenter en fluide froid le condenseur et la cuve à dessiccation par des groupes frigorifiques différents, mais cette solution accroît considérablement le prix de revient des appareils.

c) Congélation.

La vitesse de congélation des produits à dessécher conditionne en partie la conservation de leur activité. Plus rapide est la congélation, meilleur est le titre en virus. Il faut donc disposer d'une source de froid à basse température, et d'un dispositif permettant de réaliser la congélation rapide du produit.

La plupart des appareils étant destinés à la lyophilisation du plasma, leurs installations de congélation rapide sont prévues pour les flacons de grand volume. Par contre la congélation rapide de produits répartis en ampoules ou flacons type "pénicilline" n'est réalisable qu'en bulot, dans un bain d'alcool où sur des étagères fluidiées.

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Il n'est pas possible de congeler en coquille, et la durée de congélation s'en trouve sensiblement accrue. De plus, l'épaisseur du produit augmente sensiblement la durée de dessiccation.

Une congélation rapide offre aussi l'avantage de donner au produit une porosité plus grande par la multiplication des cristaux de glace et leur faible dimension. La réhydratation du produit s'effectue alors dans de meilleures conditions.

d) Dessiccation.

Elle s'effectue en deux temps. Dans le premier, une intense sublimation tend à abaisser la température du produit, auquel il faut fournir de la chaleur pour éviter l'arrêt de la dessiccation par suite d'un refroidissement trop intense.

Ce temps se termine lorsque la teneur en humidité, résiduelle du produit avoisine 5 %. La seconde phase commence alors. Le produit, même en l'absence de tout chauffage, n'étant plus refroidi par la sublimation de la glace, tend à se rechauffer, et à atteindre la température de l'ambiance. Pour certains produits, comme le plasma, il n'y a aucun inconvénient à laisser se rechauffer le produit, et l'on peut même le porter à une température de +40°C, afin d'accélérer l'évaporation des dernières traces d'eau. Par contre, en ce qui concerne les virus-vaccins, certains sont très sensibles à l'action de la chaleur, et un réchauffement à la température de l'ambiance (+25 à +35°C) pendant quelques heures suffit à diminuer sensiblement le nombre d'unités virulentes.

Des expériences portant sur du virus bovipestique lapinisé ont montré qu'une dessiccation finale de 8 heures à la température ambiante entraînait une perte d'activité d'environ 90 %.

Par contre, si la dessiccation finale était menée pendant 16 heures à +4°C la baisse du titre du virus n'excédait pas 20 %.

Il est donc nécessaire de disposer d'appareils permettant de maintenir le produit à une température déterminée, supérieure ou inférieure à l'ambiance.

e) Problèmes Connexes.

Ils concernent en particulier l'emploi de milieux protecteurs, destinés à limiter au minimum la perte d'unités virulentes qui survient pendant la lyophilisation. De nombreuses formules ont été proposées, mais il semble qu'il faille s'en tenir, en ce qui concerne les virus vaccins, à l'emploi du sérum (l'espèce en importe peu) comme milieu de base, auquel on adjoint un sucre (glucose, ou mieux lactose) pour faciliter la redissolution, et des phosphates pour tamponner le milieu.

Tout milieu destiné à la dilution des suspensions mères de virus en vue de leur lyophilisation devra donc renfermer une proportion de sérum variant de 50 à 80 %.

Par ailleurs, le conditionnement du produit s'achève par la fermeture des récipients sous vide, ou en atmosphère inerte.

Les vaccins fragiles sont jusqu'ici, en règle générale, conservés sous un vide plus ou moins poussé. Quelques essais de conservation sous azote n'ont abouti qu'à des mécomptes, la viabilité du produit étant abolie après une courte période.

Ces échecs semblent imputables à la mauvaise qualité de l'azote employé, renfermant une proportion notable d'impuretés.

L'emploi récent d'azote rectifié, importé d'Europe, promet une conservation équivalente à celle observée sous vide.

2 - Améliorations possibles.

Face aux difficultés rencontrées, il a été nécessaire de trouver des palliotifs, afin d'obtenir des appareils à lyophiliser conçus pour des régions tempérées le meilleur rendement possible dans les conditions tropicales.

Certains appareils présentent des caractéristiques qui leur permettent d'éviter les difficultés signalées :
La congélation s'effectue dans un appareil spécial , comportant une cuve à alcool refroidi à -50°C par un groupe frigorifique puissant spécialement affecté à cet usage.

La dessiccation est réalisée dans un autre appareil, où le piège à BUEMS, constitué par un évaporateur tubulaire tapisse la paroi interne de la cuve de dessiccation, le produit étant placé au centre. Cette disposition évite tout échange de chaleur entre l'ambiance et le produit, et la température de celui-ci est seulement déterminée par le chauffage qui lui est appliqué.

Enfin, les performances des groupes frigorifiques sont améliorées par l'adjonction d'un système refroidisseur d'eau qui permet le fonctionnement des appareils dans des conditions analogues à celles des pays tempérés.

Un tel appareil est évidemment l'outil idéal en régions tropicales, mais son prix de revient particulièrement élevé en restreint l'emploi.

C'est pourquoi, lorsque des appareils moins perfectionnés sont utilisés, il peut être conseillé de les placer dans une chambre maintenue à la température maxima que peut supporter le produit en fin d'opération sans dénaturation.

En effet, les apports excessifs de chaleur dus à la température ambiante sont supprimés. Le refroidissement des condenseurs s'effectue dans d'excellentes conditions, soit par de l'air à +8°C soit par de l'eau rafraîchie par un dispositif simple (serpentin à ailettes - type radiateur d'automobile - placé sous l'évaporateur de la chambre froide). Par la diminution puis l'arrêt du chauffage à la fin de la première phase de dessiccation on limite le réchauffement du produit au maximum compatible avec sa conservation, qui est la température de l'ambiance. En fin d'opération, l'appareil est rempli d'azote rectifié et le produit se trouve à la même température que la chambre, ce qui évite toute condensation. Les ampoules ou flacons sont bouchées sommairement au caoutchouc, puis scellés définitivement sous vide modéré.

Les dépenses d'équipement sont élevées : isolation de la chambre, équipement frigorifique puissant en raison du fonctionnement des appareils à l'intérieur, mais les dépenses de fonctionnement sont restreintes et largement compensées par les avantages d'un travail en milieu favorable. Les appareils ne semblent nullement affectés par le séjour à cette température : un appareil à lyophiliser fonctionne depuis six ans dans ces conditions et a effectué sans incident notable plus de dix mille heures de marche.

3 - Limites de la méthode.

La stabilisation par lyophilisation des produits biologiques n'est cependant pas absolue, et il est nécessaire d'en reconnaître les limites.

En effet, si certains produits (nous envisageons particulièrement les vaccins bactériens ou les virus) supportent après dessiccation des températures relativement élevées, d'autres restent particulièrement sensibles à la chaleur même en cet état. Les virus-vaccins bovipestiques modifiés exigent ainsi une conservation constante sous glace.

Sans nul doute, ils pourraient supporter une température légèrement supérieure, mais la présence de la glace constitue un critère facile du degré thermométrique. Cette nécessité de conservation sous froid est le principal facteur limitant actuellement l'emploi des virus-vaccins, car l'établissement d'une chaîne du froid pose de sérieux problèmes en régions tropicales. Les zones d'élevage extensif sont caractérisées par un faible peuplement humain, des voies de communications précaires et des distances considérables à parcourir d'un centre à l'autre. Le ravitaillement en glace des équipes de vaccination demande une organisation rigoureuse, des moyens de transport adéquats et entraîne des dépenses élevées, compensées il est vrai par l'abaissement du prix de revient des vaccins et une durée de protection accrue.

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- C O N C L U S I O N -

La stabilisation des virus-vaccins par lyophilisation est d'une utilité indiscutable dans les régions subtropicales.

Mais les conditions de climat (chaleur et humidité) créent quelques difficultés à la mise en oeuvre du procédé.

La température ambiante élevée diminue le rendement des groupes frigorifiques, et accroît les pertes en unités virulentes résultant du processus de dessiccation.

Pour obtenir de bons résultats, il est nécessaire de recourir à certains types d'appareils dont les caractéristiques permettent d'échapper aux inconvénients découlant du climat, ou de créer autour des autres types d'appareils une ambiance convenable, en les plaçant dans une chambre réfrigérée.

D'excellents résultats ont été obtenus par ce simple système qui ménage les appareils et diminue considérablement les pertes en unités virulentes au cours de la lyophilisation.

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LYOPHILISATION OF VIRUS VACCINES IN THE TROPICS

By Ives GILBERT,
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Dakar, Senegal

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LYOPHILISATION OF VIRUS VACCINES IN THE TROPICS

By
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DAKAR, SENEGAL.

The stabilisation of virus vaccines is indispensable for their use under subtropical conditions. Stabilisation can be achieved by the process of cryodessication or lyophilisation.

However, a tropical climate, characterised by high temperatures and frequently by high relative humidity, creates unfavourable conditions for the application of this method.

The refrigerating installations, used for producing the cold necessary for the rapid freezing of the products and for the elimination of water vapour released during desiccation, operate with a poor yield owing to the high temperature of the fluids used for refrigeration (air or water).

Furthermore, several of these apparatuses do not possess any devices for cooling the product in the course of desiccation to a temperature below that of the ambient room temperature, and this causes a heavy loss of activity of the resulting product.

These disadvantages may be eliminated by two possible solutions. In the event of acquiring new equipment and disposing of sufficient financial means, specially adapted equipment may be selected, viz. a refrigerating installation that is independent of the sublimator, feeding the condensers of the refrigerator with a cooled fluid (air or water), and such arrangement of the sublimator which would allow maintaining at a controlled given temperature the products during desiccation.

In the event of plant already in service, it is advisable to place it in a refrigerated room, the temperature of which will be calculated according to the maximal temperature tolerated by the products to be desiccated.

Under the above conditions, it is possible to considerably reduce the loss in activity resulting from the process, and to obtain products of markedly improved activity.

Lyophilisation alone does not ensure, however, complete stabilisation, and in the case of a number of virus vaccines it is essential to store and preserve them in refrigerated condition even in the desiccated state.

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Point de l'ordre du jour : C. 4. 3

Sénégal

PROBLEMES DE ROTATION POUR LA CULTURE DE L'ARACHIDE AU SENEGAL, DENSITES DE SEMIS ET DESINFECTION DES SEMENCES

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et P. GILLIER,
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Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

NOTES

1. Les mémoires choisis pour être présentés en séance générale pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

2. Les mémoires choisis pour être présentés en séance spéciale pourront être obtenus à la Conférence dans l'une seulement de ces langues officielles.

3. Les résumés qui ont été rédigés pour tous les mémoires par les auteurs de ceux-ci pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

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REPUBLIQUE DU SENEGAL

PROBLEMES DE ROTATION POUR LA CULTURE DE L'ARACHIDE AU SENEGAL - DENSITES DE SEMIS ET DESINFECTION DES SEMENCES.

(A. BOCKELEE-MORVAN, Chef du Secteur de l'I.R.H.O. au SENEGAL
P. GILLIER, Chef du Service Arachide de l'I.R.H.O.)

Première partie : PROBLEMES DE ROTATION POUR LA CULTURE DE L'ARACHIDE AU SENEGAL

1.- Introduction

La zone arachidière du Sénégal couvre 3.200.000 hectares, dont 1.200.000 cultivés presque exclusivement en arachide (715.000 ha) et mils (450.000 ha) (statistiques 1958). Ces chiffres pris globalement peuvent laisser supposer qu'un équilibre satisfaisant existe entre la culture et le sol. En fait il n'en est rien, et les successions culturales ont généralement les caractéristiques défavorables suivantes :

a)- plusieurs années de culture successives jusqu'à ce que la chute des rendements oblige le cultivateur à mettre le sol en repos pour une durée variable,

b)- succession légumineuse-céréale peu observée, ce qui accélère la baisse de fertilité du sol due à la culture continue.

2.- Evolution de la fertilité dans le cas de la culture continue arachide-mil

a)- L'évolution de la fertilité du sol en culture continue arachide-mil est suivie à Darou depuis 1952, sur un essai de fumure minérale. La fumure minérale est appliquée seulement tous les trois ans pour permettre de tester les effets résiduels des engrais, soit sur arachide, soit sur sorgho.

b)- La comparaison entre les parcelles recevant ou non une fumure minérale N P K montre l'évolution suivante des rendements après dix ans d'expérimentation :

i) sans engrais, les rendements en arachide baissent rapidement les premières années pour se stabiliser semble-t-il autour de 1.200 à 1.300 kg de gousses à l'hectare. Cette baisse est sensible : presque 50% sur les rendements derrière défriche (2.280 kg/ha).

ii) l'apport d'engrais NPK permet d'obtenir, l'année de l'application, des rendements de l'ordre de 2.300 kg à l'hectare, équivalents au rendement initial.

iii) les rendements initiaux en sorgho étaient de l'ordre de 900 kg de grain à l'hectare. Ils ont baissé très rapidement pour n'être plus, en dixième année de culture, que de 150 KG hectare sans engrais et 480 kg/ha avec engrais.

c)- L'apport d'engrais permet donc de maintenir les rendements de l'arachide à un niveau élevé dans le cas de la culture continue arachide-mil. Mais l'engrais est insuffisant pour maintenir les rendements en mil qui tombent en quelques années à un niveau trop bas pour rémunérer le travail du cultivateur.

3.- Expériences de rotation mettant en oeuvre la jachère naturelle

a)

i) Le maintien de la fertilité des sols nouvellement cultivés et la reconstitution de celle des sols épuisés par des cultures successives sans fertilisation ni amendements ne peuvent être assurés par la seule utilisation des engrais.

ii) La solution de ce problème a été recherchée sur les Points d'Essais de l'I.R.H.O. au Sénégal dans la mise au point de rotations à succession culturale courte (trois années de culture) suivie d'une période de régénération par la jachère naturelle. Des essais de longue durée ont été mis en place en 1952 à LOUGA, TIVAOUANE et DAROU comparant les rotations suivantes:

- Arachide-mil-arachide - deux ans de jachère
- Arachide-mil-arachide - trois ans de jachère
- Arachide-mil-arachide - six ans de jachère

b)- Reconstitution de la fertilité d'un sol à LOUGA

i) La zone de Louga est très anciennement cultivée. Les pluies sont peu abondantes (moyenne 420 mm) et mal réparties. L'essai a été implanté sur un sol ferrugineux tropical très appauvri et la première année, les rendements en arachide ne furent que de 355 kg à l'hectare malgré une pluviométrie favorable.

ii) Après deux années de jachère, le rendement de l'arachide est en moyenne de 650 kg/ha sans engrais, et 810 kg/ha avec engrais. Après six ans de jachère, le rendement passe à 850 kg/ha sans engrais et 1160 kg/ha avec engrais.

iii) Bien que le nombre d'années d'expérience soit insuffisant pour se prononcer de façon définitive, compte tenu des très grandes variations de la pluviosité, on peut avancer d'après ces résultats qu'il est nécessaire, pour la zone nord, de mettre en défens les sols cultivés de longue date pendant quatre ou cinq ans pour retrouver une fertilité convenable. Par la suite, une succession culturale arachide-mil-arachide avec une fumure minérale et trois ans de jachère au moins permettra de maintenir la fertilité du sol à un niveau convenable.

c)- Maintien de la fertilité. A Tivaouane et Darou les essais furent implantés en 1952 sur des sols non cultivés depuis de longues années et recouverts d'une jachère importante.

i) essai longueur de jachère de Tivaouane

a) l'essai est situé en sol dior. La pluviosité moyenne est de 606 mm. L'aléa principal de la culture de l'arachide est la "rosette", maladie qui,en 1954 et 1957, a réduit les récoltes dans des proportions considérables.

b) les rendements de l'arachide augmentent avec la durée de la jachère :

- après 2 ans de jachère, 1090 kg/ha sans engrais,1420 avec eng.
- après 6 ans de jachère, 1420 -- -- --- ,2250 - -

On peut préconiser pour cette région une rotation comportant, après trois ans de culture, une durée de jachère de trois ans.

ii) essai longueur de jachère de Darou. La pluviosité moyenne à Darou est supérieure à 800 mm et toujours suffisante pour l'arachide. Un essai de longueur de jachère a été mis en place en 1952 sur sol rouge faiblement ferralitique.

a)- les rendements moyens sur défriche de cet essais sont de
1785 kg d'arachide à l'hectare sans engrais
2450 -- -- avec engrais

b)- les rendements moyens en arachide sont de 1670 Kg/ha sans engrais et 2930 kg/ha avec engrais après deux ans de jachère. Ils n'augmentent pas après une durée plus longue de celle-ci. Dans cette région, une courte jachère de deux ans suffit à maintenir les rendements à un niveau élevé à condition que les cultures aient reçu une fumure minérale.

c)- les rendements moyens en mils (sorgho) augmentent peu avec la durée de la jachère. L'apport d'engrais permet de les maintenir à un niveau moyen de 1000 kg à l'hectare correspondant au potentiel de fertilité initial de ce type de sol pour le sorgho.

d)- Traitements de la jachère.

i) Les parcelles des essais de longueur de jachère sont subdivisées pour étudier différents traitements :
(x) jachère laissée telle quelle pendant toute sa durée et brûlée seulement à la mise en culture,
(xx) jachère coupée en septembre et laissée sur place,
(xxx) jachère coupée et compostée en septembre,
(xxxx) jachère brûlée en place chaque année à la fin de la saison sèche.

ii) L'examen des rendements de l'arachide venant après ces divers traitements montre que le meilleur est, dans tous les cas, la jachère laissée telle quelle et brûlée avant la mise en culture. A Louga, la différence avec les autres traitements est importante, la jachère ne pouvant assurer un couvert suffisant du sol en une seule année.

e)- Importance de la fumure minérale.

i) Les formules d'engrais appliquées sur les essais de longueur de jachère ont été déterminées, pour chaque région, par des essais factoriels. L'engrais augmente non seulement les rendements des cultures d'arachide ou de mil sur lesquelles il est appliqué, mais il favorise également le développement de la jachère qui suit.

ii) On a constaté à Darou que les taux d'azote, de carbone et d'humus étaient plus élevés sur les parcelles ayant reçu de l'engrais que sur celles n'en ayant pas reçu, ce qui détruit l'hypothèse selon laquelle la fumure minérale accélèrerait la destruction de la matière organique.

iii) Les augmentations de rendement dues à l'engrais sont partout rentables dès leur année d'application sur l'arachide, la quantité de gousses supplémentaires par kg d'engrais apporté aux faibles doses que nous utilisons étant environ de 3 kg. à Louga, 5 kg. à Tivaouane, 7 kg. à Darou.

Deuxième partie - DENSITE DES SEMIS POUR L'ARACHIDE ET DESINFECTION DES SEMENCES.

1.- Introduction

a)- Dès 1950, l'I.R.H.O. a pu montrer que certains organo-mercuriques et les sels de thiourame avaient non seulement un effet direct favorable sur la levée, mais également un effet secondaire très sensible sur la production et la vigueur des plantes indépendamment du phénomène de compétition.

b)- On comprend alors qu'en matière d'étude de densité de semis, il est important de faire intervenir le facteur désinfection des semences qui est loin d'être négligeable. Les recherches furent poursuivies, d'abord sur un plan théorique pour déterminer la densité optimum, puis sur un plan pratique en étudiant les incidences de la désinfection des semences, de l'utilisation de l'engrais et de la densité de semis sur les rendements. Enfin, des enquêtes chez les cultivateurs permirent de mesurer avec précision sur un grand nombre de points les résultats obtenus.

2.- Etudes théoriques selon la méthode Marchal.

Ce dispositif adapte à l'arachide un schéma expérimental dû à G. MARCHAL (cf: bulletin technique n° de l'I.R.C.T.1952)
Les essais ont été exécutés sur plusieurs variétés.

a)- variétés hâtives. Bien que le rendement par plante diminue constamment quand la densité augmente, le rendement à l'hectare augmente régulièrement jusqu'à des densités de 400.000 pieds/ha. Le gain de récolte, compte tenu de la consommation de semences, est notable jusqu'à 250.000 pieds/ha.

b)- variété tardive 28.206 (semi-érigée). On peut estimer que le rendement maximum est atteint à la densité de 150.000 plantes/ha et qu'il est suffisant d'atteindre 125.000 plantes à l'hectare.

c)- variété tardive 31-33 (rampante). Les rendements, consommation de semences déduites, continuent à croître jusqu'à 115.000 pieds/ha, mais 100.000 plantes semblent suffisantes pour cette variété rampante.

3.- Etudes au champ.

Les densités optimum trouvées dans les expérimentations en petites parcelles sont en général sous-estimées par rapport à la grande culture. C'est pourquoi les expériences furent reprises en essais plus importants dont les résultats ont montré :

a)- que la densité de semis doit être plus élevée avec engrais : sans engrais on n'a pas intérêt à dépasser 80.000 graines/ha pour les variétés tardives, alors qu'avec engrais il est avantageux de semer à 110.000 graines/ha.

b)- que l'augmentation de rendement due à l'engrais est plus élevée à forte densité.

c)- c'est donc en cumulant les trois facteurs : désinfection de semences, semis à 110.000 graines/ha, engrais, qu'on obtiendra le bénéfice maximum.

4.- Etudes en cultures indigènes et confirmation à grande échelle de la relation densité-rendement.

La relation densité-rendement a été vérifiée sur plus de 500 parcelles d'1/3 d'hectare, ayant reçu ou non de l'engrais, au cours des quatre campagnes 1956, 1958, 1959, 1960. Il a été confirmé que c'est à forte densité que l'effet de l'engrais est maximum. Les champs semés à 110.000 graines/ha et ayant reçu de l'engrais ont eu des rendements très élevés, supérieurs en moyenne à 2.200 kg/ha. Des sondages effectués dans la zone arachidière du Sénégal ont montré que très peu de semis sont faits à la densité optimum. Il est donc nécessaire de vulgariser le semis à 110.000 graines à l'hectare si l'on veut obtenir un bon effet de l'engrais utilisé par les cultivateurs.

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Senegal

PROBLEMS OF ROTATION IN GROUND-NUT GROWING IN SENEGAL : SEED DISINFECTION AND DENSITY OF SOWING

By A. BOCKELEE-MORVAN,
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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

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No. 1544

PROBLEMS OF ROTATION IN GROUND-NUT GROWING IN SENEGAL - SEED DISINFECTION AND DENSITY OF SOWING

By

C.4.3.

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and
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SUMMARY

Part I

The long-term experiments carried out in Senegal for the purpose of studying the questions of rotation and of maintenance of fertility described in this report examine the influence of land lying fallow during various periods, and its treatment following a three year cultural cycle of ground-nuts/millet, or sorghum/millet.

It was demonstrated that according to the climatic areas concerned a return to the initial fertility potential of the soils in question (cultivated after having lain fallow for long periods) was dependent on the ground lying naturally fallow for varying periods:

2 years in the south (area with 800 mm. of water per annum)
3 years (minimum) in the centre (area of 500/600 mm.)
4 years and over in the north (450 mm. area).

The system of burning off prior to cultivation proved the best treatment for this naturally fallow land.

Mineral fertilisers applied sparingly to land under ground-nut and sorghum cultivation produced considerably increased yields, and after several cultivation cycles enabled the production of stablised yields of approx. 2 (metric) tons per hectare.

The use of mineral fertiliser enabled the humus, carbon and nitrogen contents to be raised.

Part II

The initial studies have shown that the disinfection of the ground-nut seeds has had a considerable effect on the crop, and also a secondary effect on the vigour of the plants.

The optimum sowing density was studied by applying the Marchal method to a number of varieties. In the case of early varieties, the increase in yield is marked up to 250,000 plants per hectare. In the case of the late varieties, the optimum density was found to be 125,000 plants per hectare for the 28.206 variety (semi-erect), and 100,000 plants per hectare for the 31.33 variety (climbing).

The density/yield relationship was studied in conjunction with the disinfection of the seed and the application of fertilisers.

In the case of the late varieties, a density of 110,000 seeds per hectare should generally be used. Fertilisers have the maximum effect where density is greatest.

These results have been confirmed by large-scale cultivation on more than 500 plots of one third of a hectare each.

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